Annex E

Methodology for Estimating Methane Emissions from Natural Gas Systems

Step 1: Calculate Emission Estimates for Base Year 1992 Using GRI/EPA Study

The first step in estimating methane emissions from natural gas systems was to develop a detailed base year estimate of emissions. The study by GRI/EPA (1995) divides the industry into four stages to construct a detailed emissions inventory for the year 1992. These stages include: field production, processing, transmission and storage (both underground and liquefied gas storage), and distribution. This study produced emission factors and activity data for over 100 different emission sources within the natural gas system. Emissions for 1992 were estimated by multiplying activity levels by emission factors for each system component and then summing by stage. Since publication, EPA has updated activity data for some of the components in the system. Table E-1 displays the 1992 GRI/EPA activity levels and emission factors for venting and flaring from the field production stage, and the current EPA activity levels and emission factors. The data in Table E-1 is a representative sample of data used to calculate emission from all stages.

Step 2: Collect Aggregate Statistics on Main Driver Variables

As detailed data on each of the over 100 sources were not available for the period 1990 through 1996, activity levels were estimated using aggregate statistics on key drivers, including: number of producing wells (IPAA 1997), number of gas plants (AGA 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997), miles of transmission pipeline (AGA, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997), miles of distribution pipeline (AGA 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997), miles of distribution services (AGA 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997), and energy consumption (EIA 1996a). Data on the distribution of gas mains by material type was not available for certain years from AGA. For those years, the average distribution by type was held constant. Table E-2 provides the activity levels of some of the key drivers in the natural gas analysis.

Step 3: Estimate Emission Factor Changes Over Time

For the period 1990 through 1995, the emission factors were held constant, based on 1992 values. An assumed improvement in technology and practices was estimated to reduce emission factors by 5 percent by the year 2020. This assumption, annualized, amounts to a 0.2 percent decline in the 1996 emission factors.

Step 4: Estimate Emissions for Each Source

Emissions were estimated by multiplying the activity levels by emission factors. Table E-3 provides emission estimates for venting and flaring emissions from the field production stage.

Table E-1: 1992 Data and Emissions (Mg) for Venting and Flaring from Natural Gas Field Production Stage

Activity	*GRI/EPA Values* Activity Data	Emission Factor	Emissions	*EPA Adjusted Values* Activity Data	Emission Factor	Emissions
Drilling and Well Completion						
Completion Flaring	844 compl/yr	733 scf/comp	11.9	400 compl/yr	733 scf/comp	5.63
Normal Operations						
Pneumatic Device Vents	249,111 controllers	345 scfd/device	602,291	249,111 controllers	345 scfd/device	602,291
Chemical Injection Pumps	16,971 active pumps	248 scfd/pump	29,501	16,971 active pumps	248 scfd/pump	29,502
Kimray Pumps	11,050,000 MMscf/yr	368 scf/MMscf	78,024	7,380,194 MMscf/yr	992 scf/MMscf	140,566
Dehydrator Vents	12,400,000 MMscf/yr	276 scf/MMscf	65,608	8,200,215 MMscf/yr	276 scf/MMscf	43,387
Compressor Exhaust Vented						
Gas Engines	27,460 MMHPhr	0.24 scf/HPhr	126,536	27,460 MMHPhr	0.24 scf/HPhr	126,535
Routine Maintenance						
Well Workovers						
Gas Wells	9,392 w.o./yr	2,454 scfy/w.o.	443	9,392 w.o./yr	2,454 scfy/w.o.	443
Well Clean Ups (LP Gas Wells)	114,139 LP gas wells	49,570 scfy/LP well	108,631	114,139 LP gas wells	49,570 scfy/LP well	108,631
Blowdowns						
Vessel BD	255,996 vessels	78 scfy/vessel	383	242,306 vessels	78 scfy/vessel	363
Pipeline BD	340,000 miles (gath)	309 scfy/mile	2,017	340,200 miles (gath)	309 scfy/mile	2,018
Compressor BD	17,112 compressors	3,774 scfy/comp	1,240	17,112 compressors	3,774 scfy/comp	1,240
Compressor Starts	17,112 compressors	8,443 scfy/comp	2,774	17,112 compressors	8,443 scfy/comp	2,774
Upsets						
Pressure Relief Valves	529,440 PRV	34.0 scfy/PRV	346	529,440 PRV	34.0 scfy/PRV	346
ESD	1,115 platforms	256,888 scfy/plat	5,499	1,372 platforms	256,888 scfy/plat	6,767
Mishaps	340,000 miles	669 scfy/mile	4,367	340,200 miles	669 scfy/mile	4,370

Table E-2: Activity Factors for Key Drivers

Variable	Unit	1990	1991	1992	1993	1994	1995	1996
Transmission Pipelines Length	miles	280,100	281,600	284,500	269,600	268,300	264,900	257,000
Wells								
GSAM Appalachia Wells [a]	# wells	120,162	121,586	123,685	124,708	122,021	123,092	122,700
GSAM N Central Associated Wells [a]	# wells	3,862	3,890	3,852	3,771	3,708	3,694	3,459
GSAM N Central Non-Associated Wells [a]	# wells	3,105	3,684	4,317	4,885	5,813	6,323	7,073
GSAM Rest of US Wells [a]	# wells	145,100	147,271	152,897	156,568	160,011	164,750	173,928
GSAM Rest of US Associated Wells [a]	# wells	256,918	262,441	253,587	249,265	248,582	245,338	246,598
Appalch. + N. Central Non-Assoc. + Rest of US	# wells	268,367	272,541	280,899	286,161	287,845	294,165	303,701
Platforms								
Gulf of Mexico Off-shore Platforms	# platforms	3,798	3,834	3,800	3,731	3,806	3,868	3,846
Rest of U.S. (offshore platforms)	# platforms	24	24	24	24	23	23	24
N. Central Non-Assoc. + Rest of US Wells	# platforms	148,205	150,955	157,214	161,453	165,824	171,073	181,001
Gas Plants								
Number of Gas Plants	# gas plants	761	734	732	726	725	675	623
Distribution Services								
Steel - Unprotected	# of services	5,500,993	5,473,625	5,446,393	5,419,161	5,392,065	5,365,105	5,388,279
Steel - Protected	# of services	19,916,202	20,352,983	20,352,983	20,512,366	20,968,447	21,106,562	21,302,429
Plastic	# of services	16,269,414	17,654,006	17,681,238	18,231,903	19,772,041	20,270,203	20,970,924
Copper	# of services	228,240	233,246	233,246	235,073	240,299	241,882	244,127
Total	# of services	41,914,849	43,713,860	43,713,860	44,398,503	46,372,852	46,983,752	47,905,759
Distribution Mains								
Steel - Unprotected	miles	491,120	492,887	496,839	501,480	497,051	499,488	468,833
Steel - Protected	miles	91,267	90,813	90,361	89,909	89,460	89,012	88,567
Cast Iron	miles	52,644	52,100	51,800	50,086	48,542	48,100	47,100
Plastic	miles	202,269	221,600	244,300	266,826	284,247	294,400	329,700
Total	miles	837,300	857,400	883,300	908,300	919,300	931,000	934,200

[a] GSAM is the Gas Systems Analysis Model (GSAM 1997) of the Federal Energy Technology Center of the U.S. Department of Energy. It is a supply, demand and transportation model.

Table E-3: Emission Estimates for Venting and Flaring from the Field Production Stage (Mg)

Activity	1990	1991	1992	1993	1994	1995	1996
Drilling and Well Completion							
Completion Flaring	5.4	5.5	5.6	5.7	5.8	5.9	6.1
Normal Operations							
Pneumatic Device Vents	567,778	578,313	602,291	618,531	635,276	655,386	691,999
Chemical Injection Pumps	36,449	37,323	39,053	40,277	41,668	43,111	45,664
Kimray Pumps	134,247	136,380	140,566	143,211	144,040	147,191	151,565
Dehydrator Vents	41,436	42,095	43,387	44,203	44,459	45,432	46,782
Compressor Exhaust Vented							
Gas Engines	119,284	121,498	126,535	129,947	133,465	137,690	145,382
Routine Maintenance							
Well Workovers							
Gas Wells	531	540	556	567	570	582	600
Well Clean Ups (LP Gas Wells)	101,118	102,725	105,878	107,870	108,494	110,868	114,162
Blowdowns							
Vessel BD	256	261	271	278	284	292	306
Pipeline BD	1,710	1,729	1,772	1,772	1,818	1,852	1,908
Compressor BD	1,548	1,573	1,627	1,662	1,687	1,730	1,802
Compressor Starts	3,462	3,518	3,640	3,718	3,773	3,871	4,031
Upsets							
Pressure Relief Valves	326	332	346	355	365	376	397
ESD	6,764	6,827	6,767	6,646	6,773	6,882	6,834
Mishaps	925	936	959	974	984	1,003	1,033